

GROUND INCREASE OF COSMIC RAY INTENSITY
ON FEBRUARY 16, 1984

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The event of February 16, 1984 is one of the two largest ground increases of solar cosmic rays (CR) in the last two cycles of solar activity. This event happened at a decrease of the 21-st cycle against a quiet background. Although at the beginning of 1984 the observed indices of solar activity $/I/$ were higher than those at the end of 1983, the day of February 16 may be characterized as very quiet. On that day the geomagnetic perturbation ($\Sigma K_p=14$, $A_p=7$) was the lowest in February. After a small Forbush decrease due to the magnetic storm of February 12-13, the CR intensity almost completely recovered by February 16. Thus, the solar particles that came to the Earth on February 16 got into a practically unperturbed magnetosphere, and the variations of secondary CR induced by these particles were not superimposed on any other substantial variations of extraterrestrial or magnetospheric origin.

In the first half of February 1984 the solar flare activity was determined mainly by two active regions and was at a rather low level. This activity was somewhat heightened beginning from February 9, when the two active regions, AR 4408 (CD 25: S 12 L 340) and AR 4413 (CD 30: S 14 L 264) increased sharply in size and within 3 days each gave two flares of medium force. The second of the active regions rapidly lowered its activity and went beyond the western disk on February 19, 1984 and practically died away. The region AR 4408 went behind the disk increasing its area, it was in the phase of increasing activity. The activity of the region AR 4421 on the eastern disk did not give noticeable effects in CR observed on the Earth.

The solar flare responsible for the ground increase of solar CR on February 16 occurred most probably in the region AR 4408 three days after it went behind the western disk. That the flare occurred far beyond the disk is probably the most important specific feature of this event. Due to this, besides the CR from the indicated flare, it was only radio emission that reached the Earth, no emission at all being observed in the optical, UV, X-ray and γ -ranges.

According to radio data, the flare of February 16 occur-

red not later than 0858 T and was accompanied by intensive bursts of types IV, III, and II. For this event the western disk is a screen for all emissions that occur below $\sim 150 \cdot 10^3$ km. The microwave burst was therefore small, whereas in the metric wave band, for which the radiation source is high in the corona, the event was rather powerful.

Figure 1 presents ground increases of February 16 for a number of neutron monitors of the world-wide net (five-minute data). The time of the beginning of the increase differs strongly for different stations. But within the second five-minute interval of the tenth hour (0905-0910 UT) a large effect was observed already for several stations. Analyzing the time variation of the counting rate for different monitors, one can obtain the following estimate of the time of arrival of first solar particles to the Earth: $t_i = (0906 \pm 01)$ UT. Thus, if one does not assume the existence of an essential delay of radio bursts relative to the time of CR generation, one may state that having rapidly overcome the 60-degree's difference between the heliolongitude of the flare and IMF lines passing near the Earth, the first flare protons came to the Earth, in fact, without any delay.

Figure 2 presents the data of the neutrino monitor on the ship "Academician Kurchatov" which was at that time in the Atlantic Ocean at the point with coordinates (at 0900 UT) $46^\circ 11'N$, $53^\circ 02'W$. By means of interpolation of the calculations made by Shea and Smart [2], we estimated the vertical cutoff rigidity for this point to be $R_c = 1.62$ GV.

By many characteristics the flare of February 16, 1984 turned out close to the largest ground increase of the last cycle, to the event of May 7, 1978. In both cases one should note a rapid arrival of particles from the Sun, a small duration of the increase, a fast rise (< 10 min. for stations with a large cutoff rigidity) and a sharp decrease of intensity. The decrease of intensity on the ship "Academician Kurchatov" can be represented in the period 0915-1015 UT in the form $\exp(-t/\tau)$, where $\tau = 15$ m (Fig.2).

The increase of February 16, 1984, the same as the increase of May 7, 1978 is characterized by a large (close to 100 %) degree of anisotropy. The anisotropic phase of the flare was positive and occupied almost the whole period when the increase was large. The largest effect was observed in the stations, which at 9 h UT "looked" along the IMF lines towards the Sun. North-American stations and the research ship "Academician Kurchatov" appeared to be in an advantageous position for recording the ground increase. The dependence on the longitude and latitude of the point of observation turned out to be even stronger than the dependence

on the cutoff rigidity, and the value of the increase (57.4 %) on the research ship "Academician Kurchatov" ($R_c = 1.62$ GV) exceeded, in particular, the value of the increase in high-latitudinal stations Alert and Thule ($R_c = 0.00$ GV) situated in the same longitudinal zone /1/.

The large anisotropy of the effect and the large duration of its anisotropic phase do not allow us in this case to determine the form of the energy spectrum of the solar CR which came to the Earth by analyzing the dependence of the increase on the cutoff rigidity. In this case the analysis of the distribution of the effect on neutrons of different multiplicity /4/ may prove to be the most effective means for determining the slope of the energy spectrum. The observations of multiple neutrons were carried out in an expedition on the research ship "Academician Kurchatov".

It seems to us that the arrival to the Earth of charged particles from a flare beyond the disk can be explained by a particle drift in the neutral layer of heliomagnetosphere. By the indirect magnetospheric data /1/, on February 16 the Earth was in the positive sector of IMF, and the neutral layer was crossing the helioequator plane $40-50^\circ$ to the west. The line of force which goes out of the flare region of heliolatitude ~ 10 can come closer to the neutral layer, which at this heliolongitude must be projected onto the southern hemisphere of the Sun. Having drifted about 60° eastward (the drift of protons in 1984 in the neutral layer near the Sun must have just this direction), the protons could get (already in the northern hemisphere) onto the IMF line which was coming to the Earth. The hypothetical way of charged particles from the flare of February 16 to the Earth is shown in Fig.3.

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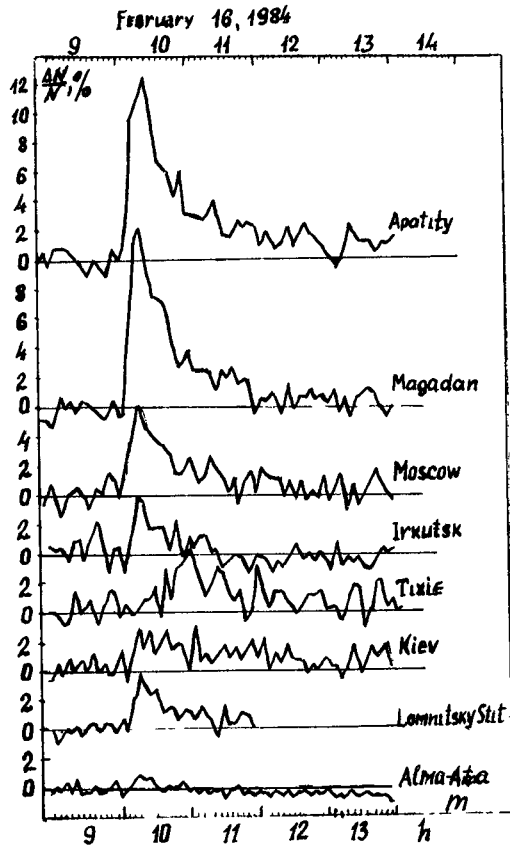


Fig. 1

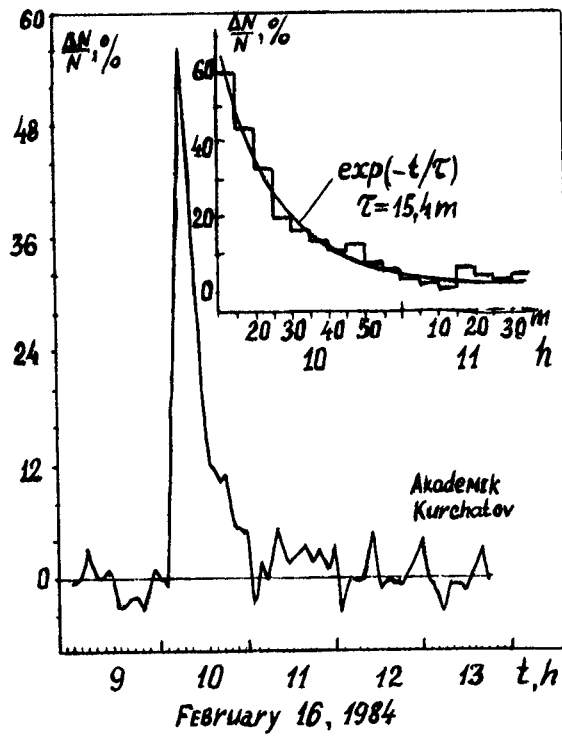


Fig. 2

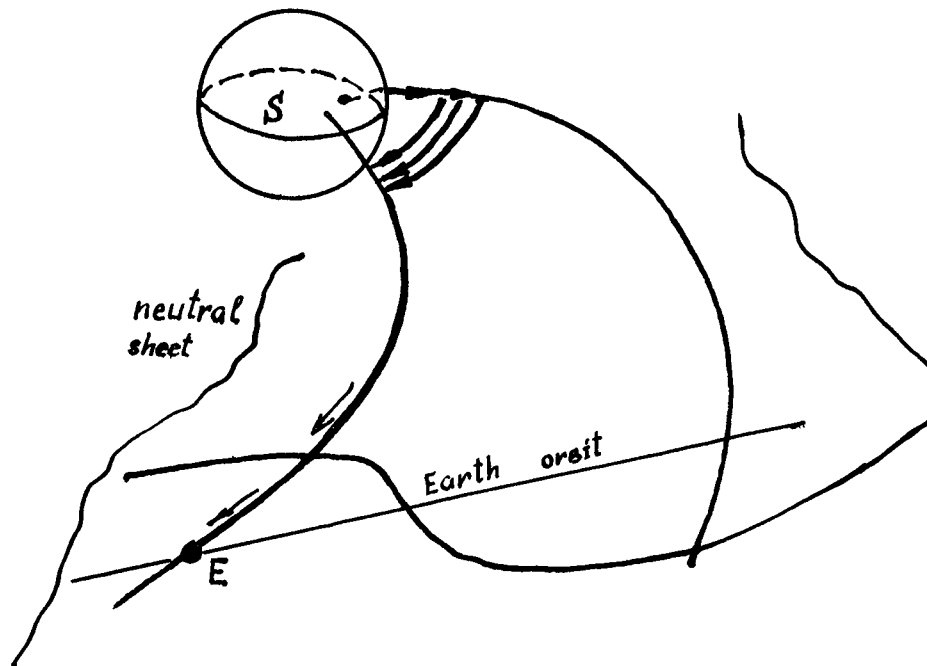


Fig. 3